REMARKS

Status of Claims

Claims 1, 7-9, 16, 18 and 20 are previously presented; claims 3-6, 11-15, 17 and 19 are remained unchanged; and claims 2 and 10 are canceled.

Double Patenting Rejections

Claims 16-20 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 2 and 9 of U.S. Patent No. 7,115,013.

In response to this rejection, attached herewith is a copy of a Terminal Disclaimer duly signed by the registered agent of the Applicants. Accordingly, it is believed that the rejection is overcome.

Claim Rejections - 35 USC §103

Claims 1, 4, 7-9, 11, 14 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Han et al. (U.S. 6,515,415 B1) in view of Dai et al. (US Patent 6,232,706 B1).

In response thereto, Applicants respectfully traverse the rejection of such claims and assert that the rejected claims are patentable.

Claim 1, as previously presented, recites in part:

A carbon nanotube-based field emission device comprising:

> a cathode electrode; and
>
> ...the carbon nanotube array being aligned perpendicular to the cathode electrode with each given growth end embedded in the cathode electrode and the corresponding root end being outwardly directed and exposed;
>
> ... the root end thereof defines a planar surface with a flatness of less than one micron across the carbon nanotube array. (Emphasis added.)

Applicants submit that the device as set forth in previously presented claim 1 is neither taught, disclosed, nor suggested by Han et al. '415, Dai et al. '706, or any of the other cited references, taken alone or in combination.

Han et al. '415 discloses a carbon nanotube field emission display. As shown in FIG. 3 and Col. 3, lines 54-56 of Han et al. '415, the carbon nanotube field emission display includes a cathode 120, a resistance layer 125 formed on the cathode 120, and carbon nanotubes 121 disposed on the resistance layer 125. The carbon nanotubes 121 are disposed by a screen printing method, a chemical vapor deposition method, an electrophoretic method, or an anodic oxidation alumina sheet cathode method.

It is known in the art of CNT production that "growth ends" are ends that are free during the growth of the carbon nanotubes and "root ends" are ends that are fixed on the substrate during the growth of the carbon nanotubes. As shown in FIG. 12 through 15C and Col. 5, lines 19-43 of Han et al. '415, when the carbon nanotubes 121 are disposed by the chemical vapor deposition method or the anodic oxidation alumina sheet cathode

method, the carbon nanotubes 121 are members of a carbon nanotube array with growth ends thereof exposed and root ends thereof formed on the resistance layer 125, which is the exact opposite to the situation provided in previously presented claim 1. Accordingly, Han et al. '415 fails to teach or suggest each and every element of claim 1.

Meanwhile, when the carbon nanotubes 121 are disposed by the screen printing method or the electrophoretic method, the carbon nanotubes 121 are members of a paste/colloidal solution and thus are not members of a carbon nanotube array, as required in previously presented claim 1.

Even if the exposed ends of the carbon nanotubes 121 can be interpreted as root ends, it is clear that the opposite interpreted growth ends of the carbon nanotubes 121 are formed on the resistance layer 125 but not embedded in the cathode 120, which has been clearly required in previously presented claim 1. The Examiner stated in the Office Action that "having the CNTs attached to the cathode is a form of embedding". Applicants **traverse the implied equivalence** of the words "attach" and "embed" and **hereby respectfully request that a showing by the Examiner**, in the form of accepted dictionary definitions, be presented **to substantiate such a position.** Absent such a showing, Applicants respectfully submit that mere "attachment" does not inherently disclose or suggest "embedding", in the manner contended by the Examiner. As such, Han et al. '415 fails to teach or suggest each and every limitation of claim 1.

Upon close inspection, as described in Col. 3, lines 54-56 and Col. 4, lines 54-56 of Han et al. '415, the carbon nanotubes 121 are deposited on the resistance layer 125. Additionally, as shown in FIG. 3 and FIG. 9B, the

interpreted growth ends of the carbon nanotubes 121 are disposed on a surface of the resistance layer 125 and are not embedded in the cathode 120. Thus, Han et al. '415 fails to teach or suggest each and every element of claim 1.

Furthermore, there is no specific disclosure or suggestion in the carbon nanotube field emission display of Han et al. '415 that the exposed ends of carbon nanotubes 121 thereof expressly defines a planar surface with a flatness of less than one micron, which has been clearly provided in previously presented claim 1. That Han et al. '415 discloses the exposed ends of carbon nanotubes 121 to be flat is not a disclosure or suggestion of the further limitation of the specific degree of flatness required. To make a geographical analogy, I could say that both Indiana and Illinois are known to be "flat" States, especially compared to the Rocky Mountain or Appalachian States. However, it would be improper for me to conclude solely from that assessment that neither State might have some substantial hills and valleys, which obviously would not be true. In relation to both the ends of carbon nanotubes 121 of the instant reference and the flat States, just knowing that they are accepted or disclosed as "flat" is not particularly a disclosure or suggestion, inherent or otherwise, of exactly how flat any of them are.

Dai et al. '706 discloses a method of making a field emission device 20. As shown in FIG. 3 and Col. 3, line 46-Col. 4, line 10 of Dai et al. '706, the method includes the following steps:

step A, a silicon substrate 22 is electrochemically etched to form a porous layer 24;

step B, catalytically active iron oxide patterns 26 are formed on the porous layer 24; and

step C, carbon nanotube bundles 28 are grown perpendicular to the substrate 22.

It is clear that the exposed top surface of the carbon nanotube bundles 28 are actually the growth ends thereof and not the root ends. Even if the exposed top surface of the carbon nanotube bundles 28 could, for the sake of argument, be interpreted as root ends, a flatness thereof is not expressly disclosed to be less than one micron. As discussed above, the mere disclosure of a "flat" surface cannot, alone, be considered an inherent teaching or a suggestion of a specific degree of flatness, as is required by claim 1.

The Examiner has interpreted flat to mean a flatness of less than one micron. However, upon close inspection, as shown in FIG. 1 and Col. 3, lines 19-32, and Col. 4, lines 11-15 of Dai et al. '706, the top surface of the carbon nanotube bundles can be flat or bowl-shaped, and the method produces mainly flat-top bundles. Dai et al. '706 is not at all specific about the degree of flatness and, if anything, would seem to suggest that a rather sizable level of variability is to be expected (i.e., "mainly" is typically open to a broad interpretation). Such an implied variability in the bundle-end contours actually would tend to teach away from a high degree of flatness for such bundles, overall. Particularly, for a flatness of less than one micron to be possible over the array, the nanotubes must extend to an essentially equal lateral position (i.e., a given height) and be of an appropriate individual flatness.

Simply put, Dai et al. '706, when considered as a whole, does not teach or suggest, with sufficient specificity, enough detail to meet the flatness

limitation of claim 1, as previously presented, instead requiring an impermissible "obvious to try" (MPEP §2145.X.B.) standard to be implemented. Therefore, there is no specific disclosure or suggestion that, with respect to the carbon nanotube bundles 28 of Dai et al. '706, the exposed ends of the carbon nanotube bundles 28 are root ends and define a planar surface with a flatness of less than one micron, as is clearly set forth in previously presented claim 1.

Accordingly, Applicants submit that the combination of Han et al. '415 in view of Dai et al. '706 fails to teach or suggest the carbon nanotube-based field emission device as set forth in previously presented claim 1. Therefore, previously presented claim 1 clearly recites novel and unobvious physical subject matter over Han et al. '415 in view of Dai et al. '706 or any of the other cited references, taken alone or in combination.

Applicants submit that the novel and unobvious physical features of claim 1 produce new and unexpected results over and above Han et al. '415, Dai et al. '706 or any of the other cited references, taken alone or in combination. The new and unexpected results related to the claimed carbon nanotube-based field emission device are associated with the embedded growth end and exposed flat root end of the carbon nanotube array. The growth ends of the carbon nanotube array are embedded in the cathode electrode, ensuring a firm retention between the carbon nanotube array and the cathode electrode and thus helping to overcome the shortcoming of the prior device, whose carbon nanotubes are apt to be pulled out of the cathode by the electrical force.

Furthermore, the exposed flat root end of the carbon nanotube array

acts as electron emission ends of the carbon nanotube-based field emission device. Thus, this flat end effect improves electron emission uniformity and stability of the manufactured device and thus helps to overcome the shortcoming of the prior device whose electron emitting surface is neither predictable nor controllable (see Paras. **[0003]**, **[0006]** and **[0027]**). Applicants' invention is therefore clearly superior to that of Han et al. '415, Dai et al. '706, or any of the other cited references, taken alone or in combination. The novel and unobvious features of Applicants' invention, which give effect to these results, are clearly recited in previously presented claim 1.

In summary, it is submitted that previously presented claim 1 is unobvious and patentable over Han et al. '415, Dai et al. '706, or any of the other cited references under § 103.

Dependent claims 4, 7, and 8, respectively, incorporate all the subject matter of independent claim 1 and add respective additional subject matter. As detailed above, it is asserted that previously presented claim 1 is allowable. Thus, it is submitted that the dependent claims 4, 7, and 8 are also allowable, and Applicants request that the rejection relating thereto be removed.

Claim 9, as previously presented, recites in part:

> A carbon nanotube-based field emission device comprising:
>
> ...a <u>cathode electrode formed on and covering the growth end</u> of the carbon nanotube array;

wherein the root end defines a planar surface which is exposed outwardly and acts as an emitter, a flatness of the planar surface of the root end of the carbon nanotube array is less than 1 micron, and the growth end is embedded into the cathode electrode. (Emphasis added.)

Applicants submit that the device as set forth in previously presented claim 9 is neither taught, disclosed, nor suggested by Han et al. '415, Dai et al. '706, or any of the other cited references, taken alone or in combination.

For reasons similar to those asserted above in relation to the rejection of claim 1 under 35 U.S.C. § 103 on Han et al. '415 in view of Dai et al. '706, Applicants submit that subject matter as set forth in claim 9 is neither taught, disclosed, nor suggest by Han et al. '415, Dai et al. '706, or any of the other cited references, taken alone or in combination.

Therefore, previously presented claim 9 is unobvious and patentable over Han et al. '415, Dai et al. '706 or any of the other cited references under § 103.

Dependent claims 11, 14, and 15 incorporate all the subject matter of independent claim 9 and add respective additional subject matter. As detailed above, it is asserted that claim 9 is allowable. Thus, it is submitted that the dependent claims 11, 14, and 15 are also allowable, and Applicants request that the rejection relating thereto be removed.

Claims 3, 5, 6, 12 and 13 are rejected under 35 U.S.C. 103(a) as being anticipated over Han et al. (U.S. 6,515,415B1) in view of Dai et al. (US Patent 6,232,706 B1) and in further view of Nakamoto (U.S. 6,097,138B1).

Dependent claims 3, 5, and 6 incorporate all the subject matter of independent claim 1, respectively, and add respective additional subject matter. As detailed above, it is asserted that claim 1 is allowable. Thus, it is submitted that the dependent claims 3, 5, and 6 are also allowable, and Applicants request that the rejection relating thereto be removed.

Dependent claims 12 and 13 incorporate all the subject matter of independent claim 9, respectively, and add respective additional subject matter. As detailed above, it is asserted that claim 9 is allowable. Thus, it is submitted that the dependent claims 12 and 13 are also allowable, and Applicants request that the rejection relating thereto be removed.

Conclusion

For all the above reasons, applicants assert that all the pending claims are now in proper form and are patentably distinguishable over the prior art. Therefore applicants submit that this application is now in condition for allowance, and an action to this effect is earnestly requested.

Applicants further note that any new rejection in the next Office Action of any of the pending claims could not be considered as having been necessitated by amendment. Accordingly, Applicants respectfully submit that such an Office Action should not be made FINAL, based upon the

guidelines set forth in MPEP §706.07(a).

Respectfully submitted,

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